Putnam (J. J.)

Contribution to the physiology of the cortex cerebri.

CONTRIBUTION TO THE PHYSIOLOGY OF THE CORTEX CEREBRI.

By JAMES J. PUTNAM, M.D.

Lecturer at the Harvard Medical School on the Application of Electricity in Nervous Diseases.

ALL those of the profession who interest themselves in physiological matters are already familiar with the experiments, made first, some years ago, by Fritsch and Hitzig, of Berlin, and latterly repeated with greater elaboration, by them, and by Ferrier, of London, which seem to prove that the cortex cerebri is not, as had been long believed, or at least not over its whole extent, incapable of responding to other stimuli besides those to whose influence it is regularly subjected.

On the contrary, it appears that when a weak current of electricity is applied to certain pretty sharply defined points which lie mainly in the convolutions bordering on and anterior to the fissures of Sylvius and Rolando, certain groups of muscles *on the opposite side, and sometimes on both sides* of the body, may be thrown into contraction. The important bearing of these observations upon cerebral physiology and pathology has not failed to gain for them the close attention of neuropathologists everywhere, and especially of Dr. Hughlings Jackson, of London, who sees in them the verification of some clinical theories of his own. The observations themselves have received corroboration from all sides, but recently an important criticism has been made on them by Dr. Eugene Dupuy,* and by MM. Carville and Duret,† and, indeed, by Hitzig himself in speaking of the experiments of Ferrier,‡ viz., that it is impossible, in using induction currents [Hitzig employs galvanic currents], to confine the irritation to limited districts of the cortex cerebri, and that the muscular contractions which attend, at least Ferrier's method of irritation, are due partly [Hitzig] or entirely [Dupuy] to the irritation of nervous masses which lie buried deeper.

The experiments here recorded were undertaken for the purpose of testing that point, but it may be well before describing them, to examine a little the adverse testimony just referred to. The criticism of Hitzig was called out by the fact that Ferrier's centres, though in the main corresponding with his, occupied a larger area, and that their position, as observed in cats, differed from that in dogs more than the

* Examen de quelques points de la physiologie du cerveau. Paris. 1873.

† Gazette Médicale de Paris, Jan. 10, 1874. Vide also review of both in the Archives of Neurology and Electrology, Vol. I., No. 1, May, 1874.

‡ Berliner Klinische Wochenschrift, Feb. 9, 1874.

other differences between these animals would have led him to believe. Into the examination of these points we do not undertake to enter.

On the part of Carville and Duret, the criticism was founded mainly upon the results of some experiments in which platinum needles, connected with a sensitive galvanometer, were introduced to different depths into the brains of animals, while the cortex was faradized in the usual manner, and they claim that the galvanometer needle was deviated, even when the distance between the platinum needles and the electrodes which furnished the current amounted to several inches. From these and other facts, to be referred to later, they drew, among others, these conclusions :—

1. That the cortical substance of the hemispheres is not excitable ; it is insensible, and does not contain special motor centres.

2. That the effects produced by faradic currents are due to direct excitation of the corpora striata and crura cerebri, as the currents penetrate to these organs.

Also, that faradic currents, however feeble, are diffused over the surface of the brain, from one point to another.

Although the distinction is not made in their report, it is most probable that Carville and Duret used the primary, and not the secondary induction currents, contrary to Ferrier's habit, otherwise they would not have been able to detect their presence by the galvanometer, for the needle of this instrument is not deflected by the currents of short duration, and whose direction is constantly changing, such as are obtained from the secondary induction coil. This is in so far of importance that the secondary currents, owing to their greater tension [power of overcoming resistance], make their way less weakened by diffusion directly through the tissue separating the wire electrodes, for, although in traversing any conductor electricity diffuses itself to some extent over the whole mass, yet the degree to which it does so is inversely proportional to its power of forcing a direct passage between the points of entrance and exit, and this power, thanks to the greater number of turns of wire of which the secondary coil is made up, belongs to the secondary induction current in greater degree than to the primary [extra] current.

Dupuy* was led to much the same conclusions as those stated, finding, as did also Carville and Duret, that " it is possible to excite, by the irritation of any point whatever of the cortex cerebri, contractions, affecting sometimes a whole limb, which is generally the fore leg and on the opposite side of the body ;" also " that (while the irritation was being made as usual) a galvanoscopic frog-preparation was thrown into contraction when its nerve touched the cortex cerebri at a point far removed from that irritated," and, further,† that nerves at the base of the brain, which have been previously cut through to prevent the transmission from above of *nervous* excitation, can be excited electrically when applications are made to the surface of the brain in the usual manner, showing to how great an extent diffusion of electrical currents may take place.

That these results were obtained as stated we have no difficulty in believing, but we do not admit that they justify the conclusions drawn.

---

* As well as for other reasons, not discussed here because not bearing on the point under consideration.

† So stated at a recent meeting of the New York Society of Neurology and Electrology. Vide New York Medical Journal, July, 1874.

The real question plainly at stake is, not, "can we produce effects due to irritation of distant parts while irritating definite points of the cortex cerebri," which is unquestionably the case, but, rather, "can we irritate the cortex cerebri to the extent necessary to produce the results claimed, *without* at the same time irritating deeper seated structures enough to call out their functional activity," and this possibility is not refuted by the experiments of Dupuy, or Carville and Duret, but receives affirmative support from our experiments, although few in number. Our plan was, to find, which was always possible, centres for definite, and nearly or quite uncomplicated, movements, and the minimal current-strength that was necessary to produce these movements, and then, with a sharp knife, to make a cut underneath them, leaving a good-sized but thin [by estimation 1 to 2 mm. thick] flap, which contained, in each case, the suppositious centre. Having done this, we found that if we irritated as before, leaving the flap *in situ*, the movements before observed did not occur.

We then turned the flap up and irritated below it. The same current strength generally failed, here also, to call out the movements, but they always appeared when the strength was slightly increased; not so, however, when the flap was turned back and adjusted, and the electrodes applied on its surface as at first, repeated trials being attended with the same results. The irritations were made with the current from the secondary coil of a Du Bois-Reymond induction apparatus, run by a single Léclanché cell, and the minimal current, which was found efficient, was strong enough to be felt distinctly by the tongue, scarcely, if at all, by the finger,* i. e. of about the strength that Ferrier also found usually sufficient.

The animals experimented upon, three in number, were dogs. The method was that usually followed, and no accidents occurred which materially interfered with the investigations. The movements obtained were, in the first experiment, extension of the opposite fore-leg; in the second, extension of opposite fore-paw, flexion of fore-leg at elbow, extension of leg at shoulder, partial extension of paw, these different phases following each other slowly, and the full result only occurring when the irritation had lasted a certain time; in the third, extension of fore-paw of the opposite, sometimes also of the same, side, and occasional slight movements of hind legs; in the fourth, well-marked closure of the opposite eye, without any other movements with the exception of occasional struggling.

Subsequent examination showed that the centres which we found agreed quite well with the corresponding ones found by Ferrier, in one instance more closely, apparently, with that given by Hitzig.

One experiment, given somewhat in detail, will serve as a type of all:

June 6.—A middle-sized, healthy dog was etherized, a good portion of the skull laid bare from the median line down to the zygomatic arch on the right side, and a small piece of bone trephined out from the middle of this surface. The opening so made was enlarged with bone-forceps to the diameter of about 1.5 c.m., the dura mater removed, and the exposed portion of brain sketched. Muscular bleeding was checked by perchloride of iron; that from the membranes, which was considerable, by light pressure with sponges.

* In no case was it necessary to make the secondary coil overlap the primary, or even to come within an inch of doing so.

Centres were sought for in vain over this surface, with irritations varying in strength from D = 15·3 cm. to D = 12·9 cm.* Once only all the muscles of the body were thrown into spasmodic contraction, which lasted after the cessation of the irritation, passing over into general struggling which made more ether necessary.

The hole was then enlarged to about 3 cm. in diameter, and the search continued, but, at first without success. This was probably because the unusually great tendency on the part of the animal to struggle violently, though probably not suffering much pain, obliged us to keep it thoroughly etherized, whereas it is only during incomplete etherization that the centres, or most of them, are irritable. At the 13th point of application, with the weak irritation D = 14·8 cm., we obtained *firm closure of left eye*, the animal being pretty well under ether, and quiet.

Cm.	Result.
With D = 16	Same as before, but less well marked.
D = 15·3	Ditto, better marked than last time.

(From this point on, the animal remained, at least at the moments of experimentation, pretty quiet. The ether was discontinued so far as to ensure that the eyes should be open, or partially so, at the proper moments.)

As superficial a section as possible was then made (at most than 1 mm. thick), but the flap left *in situ*.

		Result.
Application made on top of flap,	D = 14·8	0
Application made on exposed surface after reflection of flap,	D = 14·8	0
Application made on exposed surface after reflection of flap,	D = 12·8	Left eye firmly closed.
Application made on top of flap after replacement,	D = 12·9	0
Application made below flap again,	D = 12·9	Closure of eye as before.
" " on top of flap,	D = 12·9	0
" " below flap,	D = 12·9	Closure of eye as before.
" " on top of flap,	D = 12·9	Possibly closure of eye to slight degree.
" " below flap,	D = 12·9	Closure of eye as at first, though not so strongly marked.
" " on top of flap,	D = 12·9	0

No other movements occurred, at the moments of experimentation, that could be regarded as due to the irritation of the brain, or that materially complicated the results stated.

These experiments were made at the physiological laboratory of the Harvard Medical College, with the kind assistance of Prof. H. P. Bowditch and Dr. Wm. James. Since their completion, the gratifying statement has come to our notice that essentially the same method has been employed by another observer, with the same results. (Braun, in *Eckhard's Beiträge zur Anatomie und Physiologie*, vii. 2; also *Centralblatt*, Berlin, June 13, 1874.)

---

* D represents the distance between the similar ends of the two coils. D = 0 would indicate that the secondary coil was slipped entirely over the primary. When D = 7·5, the anterior end of the secondary coil was just level with the posterior end of the primary.

Re-printed from the Boston Medical and Surgical Journal, July 16, 1874.